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Direct Identification of Crisis Periods on the CEE Stock Markets: The Influence of the 2007 U.S. Subprime Crisis

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Abstract

The main goal of this paper is a direct identification of crisis periods on the eight Central and Eastern European (CEE) stock markets, and, for comparison, on the U.S. market. We employ a statistical procedure of dividing market states into up and down markets. Our aim is to examine whether crisis periods are common in various countries, and the results confirm Oct 2007 – Feb 2009 as the common period of the recent global financial crisis, except for Slovakia. Moreover, we investigate the effect of increasing cross–market correlations in the crisis period in the context of contagion, applying both standard contemporaneous correlations and volatility-adjusted correlation coefficients. Our results confirm that accommodating heteroskedasticity is crucial for detecting contagion across stock markets. The data consists of monthly logarithmic returns of the major CEE and the U.S. stock market indexes, in the period May 2004 – April 2013.

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"Keywords: CEE stock markets; crisis period; market states; cross-market correlations; contagion"

1. Introduction

An event that had significant impact on a group of eight Central and Eastern European (CEE) emerging markets was the accession to the European Union (EU) on the 1st of May 2004. These eight countries, in order of decreasing population size are: Poland, the Czech Republic, Hungary, Slovakia, Lithuania, Latvia, Slovenia and Estonia. The CEE economies are interesting in many respects, especially in the context of the influence of the 2007 U.S. subprime crisis.

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There have been numerous studies of the influence and consequences of the 2007 U.S. subprime crisis for developed and emerging stock markets in the world. As the aim of this paper is a direct statistical identification of crisis periods in the CEE equity markets, we focus our analysis of previous literature on the studies related mostly to the European economies. According to the literature, e.g. (Calomiris, 2009; Brunnermeier, 2009; Claessens et al., 2010), the financial crisis timeline, from the U.S. perspective, was market by the following events: (1) the increase in subprime delinquency rates in the spring of 2007, (2) the ensuing liquidity crunch in late 2007, (3) the liquidation of Bear Stearns in March 2008, and (4) the failure of Lehman Brothers in Sept 2008. The U.S. economy officially slipped into recession following the peak in Dec 2007. The crisis began in the U.S., but initially it did not affect the CEE markets to the same extent. Claessens et al. (2010) identified five groups of countries based on the date they were affected by the crisis. They advocated that Latvia and Estonia entered recession at 2008Q1, Hungary at 2008Q2, together with the major Western European countries, i.e. the U.K., France and Germany, Lithuania and Slovenia at 2008Q3, while Poland and the Czech Republic slipped into recession in 2008Q4. Slovakia entered recession with a delay, to wit in 2009Q1. As a matter of fact, the Baltic region stock markets were among the most affected by the crisis. Lane and Milesi-Ferretti (2011, p. 19) showed that Lithuania, Latvia, and Estonia entered the group of the "Top 5" crisis countries. Marer (2010) analysed the CEE economies among other Eastern European countries in the context of commonalities and differences during recent financial crisis. He stressed that the global liquidity crisis hit the most vulnerable economies (i.e. Hungary and the Baltic States) immediately and hard, while the region's less vulnerable countries (i.e. Poland, the Czech Republic, Slovenia and Slovakia) were less affected.

It is important to note that there is no unanimity in determining the global crisis period among the researchers. In particular, there is no agreement about the pre-, post, and crisis periods. For example, Pisani-Ferry and Sapir (2010) proposed two phases of crisis in the EU. They advocated that the first phase started in Aug 2007 with a general liquidity strain. The second phase started in Sept 2008 with the bankruptcy of Lehman Brothers. Similarly, Mishkin (2011) divided the financial crisis into two distinct phases: the first from Aug 2007 to Aug 2008, called the U.S. subprime mortgage crisis, and the second, which started in mid-Sept 2008, known as the global financial crisis. Dooley and Hutchison (2009) investigated the links between the U.S. and a broad range of emerging markets over a subprime crisis period from Feb 2007 to March 2009. They analysed three phases of the subprime crisis and they argued that the first phase of the crisis ran from Feb 27, 2007. The authors stressed that the emerging markets were somewhat insulated and decoupled from the U.S. from early 2007 to summer 2008. Calomiris et al. (2012) considered three 'crisis shocks' related to key features of the 2007 – 2008 crisis for the emerging and developed economies: the collapse of global trade, the contraction of credit supply, and selling pressure on firm's equity. They advocated Aug 2007 – Dec 2008 as the crisis period. Bartram and Bodnar (2009) proposed a detailed investigation of the global financial crisis 2008/2009 and provided a timeline of events and policy actions for the crisis in equity markets. They advocated Jan 1, 2007 – Sept 12, 2008 as the pre-crisis period, and Oct 28, 2008 – Feb 27, 2009 as the post-crisis period. As a matter of fact, their choice of the post-crisis period seems to be rather controversial in the light of the stock market indexes continuing their decline during this period (cf. Figures 1-2). Olbrys and Majewska (2013) proposed Feb 27, 2007 – March 9, 2009 as a crisis period, based on the S&P500 index decline. The overall S&P500 index fell from 1399.04 (Feb 27, 2007) to 676.53 (March 9, 2009) and it lost 51.64% of its previous value during the crisis period.

The main goal of this paper is a direct identification of crisis periods on the eight CEE stock markets, and, for comparison, on the U.S. market. The sample period begins with the CEE accession to the EU on the 1st of May 2004, and ends on April 30, 2013, and it includes the 2007 U.S. subprime crisis period. We employ a statistical procedure of dividing market states into bullish and bearish markets (Pagan, Sossounov, 2003). The study whether states are common during the crisis period is a crucial topic because of many practical implications in light of market globalization, as well as international portfolio choice and diversification. Our results confirm Oct 2007 – Feb 2009 as the common period of the recent global financial crisis, except for Slovakia. Furthermore, we investigate the effect of increasing cross–market correlations in the crisis period in the context of contagion, applying both standard contemporaneous correlations and volatility-adjusted correlation coefficients proposed by Forbes and Rigobon (2002), who stressed that market return volatility can bias standard cross-correlations. To the best of the authors' knowledge, no such research has been undertaken jointly for the CEE and the U.S. stock markets.

The remainder of this paper is organized as follows. Section 2 specifies the methodological background of the statistical method of dividing market states into up and down markets. In Section 3, we propose a brief analysis of the effect of increasing cross–market correlations in down markets, especially in crisis periods. In Section 4, we present data description and empirical results on the main indexes of the CEE and U.S. stock markets. Section 5 recalls the main findings and presents the conclusions.

2. Procedure for Identification of Up and Down Markets

Lunde and Timmermann (2000) stressed that there is no generally accepted formal definition of up and down markets in finance literature. They created an algorithm for detecting bull and bear states. Cooper et al. (2004) identified an up or a down market when the past 12-, 24-, or 36-month market return is non-negative (negative), respectively. Pagan and Sossounov (2003) developed an algorithm that seemed to be successful in locating periods in time that were considered bull and bear markets in U.S. equity prices. They tested monthly data of the S&P500 index, in the period from Jan 1835 to May 1997. Lee et al. (2011) proposed a modified version of the Pagan-Sossounov method of dividing market states into bullish, bearish, and range-bound markets. We employ a three-stage procedure of dividing market states into up and down markets (Olbrys, Majewska, 2014). Our methodology builds on Pagan and Sossounov (2003). In the first step, we conduct a preliminary identification of turning points, i.e., peaks and troughs, based on the conditions (1) – (2), respectively:

$$\ln P_{t-8},\ldots,\ln P_{t-1} < \ln P_t > \ln P_{t+1},\ldots,\ln P_{t+8} \tag{1}$$

$$\ln P_{t-8},\ldots,\ln P_{t-1} > \ln P_t < \ln P_{t+1},\ldots,\ln P_{t+8} \tag{2}$$

where P_t represents the market index of month t, and from successive peaks/troughs we choose the highest/deepest one, respectively. Pagan and Sossounov (2003) stressed that in the business cycle literature an algorithm for describing turning points in time series was developed by Bry and Boschan (1971), but they modified this algorithm by taking the eight months window (instead of six) in marking the initial location of turning points. The main goal was not to smooth any of the monthly, already smoothed, data.

In the second step, we rule out the phases (peak-trough or trough-peak) that last for less than four months, and cycles (peak-trough-peak or trough-peak-trough) that last for less than sixteen months. Pagan and Sossounov (2003) pointed out that in business cycle dating the minimal cycle length is fifteen months, hence sixteen months were chosen to create a symmetric window of eight periods. Furthermore, they advocated four months as the minimal length of a phase.

In the last step we calculate the amplitudes A for each phase (amplitude is the difference in the natural logs of the index value in subsequent turning points). During the bull/bear market period there must be a large enough (of at least 20%) rise/fall in the index value. This means that the amplitude of a given phase must fulfill the condition $A \geq 0.18$ or $A \leq -0.22$ for the bull or bear market period, respectively (Olbrys, Majewska, 2014, p. 255). The identification of market states is a problem of considerable importance, as Cooper et al.

(2004) among others obtained that profits to investment strategies depend critically on the state of the market.

3. Effect of Increasing Cross – Market Correlations in the Crisis Period

International equity market correlation is a very important topic because of many practical implications, especially in the context of international portfolio choice and diversification. For example, Longin and Solnik (2001) studied the conditional correlation structure of international equity returns and derived a formal statistical method, based on the extreme value theory. They found that conditional correlation increases in bear markets, but not in bull markets. Goetzmann et al. (2005) examined the correlation structure of the major world markets over 150 years. They found that international equity correlations change dramatically through time, thus the diversification benefits to global investing are not constant. Hong et al. (2007) provided a model – free test for asymmetric correlations in bear versus bull markets. They evaluated the economic significance of incorporating asymmetries into investment decisions.

Although there is no unanimity in research regarding the reasons of increasing cross-market correlations in crisis periods, the majority of researchers agree that during crucial market events correlations change dramatically. This evidence is often justified by the authors as the consequence of contagion. As a matter of fact, contagion is not simply revealed by increased correlation of market returns during a crisis period, e.g (Edwards 2000; Bekaert et al. 2005) and references therein. Among others, Rigobon (2002, p. 4) stressed that "(…) there is no accordance on what contagion means". Furthermore, Forbes and Rigobon (2002) defined contagion as a significant increase in cross-market linkages after a shock to one country (or group of countries), but they stated that this definition is not universally accepted. They stressed that heteroskedasticity in market returns biases tests for contagion based on correlation and correlation coefficients are conditional on market volatility. The authors proposed the following correction for the volatility bias:

$$\hat{\rho}_{VA} = \frac{\hat{\rho}_C}{\sqrt{1+\delta\left[1-(\hat{\rho}_C)^2\right]}}, \tag{3}$$

where $\hat{\rho}_{VA}$ is the unconditional volatility-adjusted cross-correlation coefficient between markets, $\hat{\rho}_C$ is the estimated conditional cross-correlation coefficient in the crisis period, and δ is the relative increase in the variance of market returns in the crisis period compared to the pre-crisis period:

$$\delta = \frac{\hat{\sigma}_C^2}{\hat{\sigma}_{PC}^2} - 1, \tag{4}$$

where $\hat{\sigma}_C^2$, $\hat{\sigma}_{PC}^2$ are the variances in the high-volatility (crisis) and low-volatility (pre-crisis) periods, respectively. By construction, it is obvious that $\hat{\sigma}_C^2 \geq \hat{\sigma}_{PC}^2$, hence $\delta \geq 0$ and $\hat{\rho}_{VA} \leq \hat{\rho}_C$, that is, during the periods of high volatility the unconditional volatility-adjusted cross-correlation $\hat{\rho}_{VA}$ will be smaller than the estimated conditional cross-correlation $\hat{\rho}_C$ between markets. The evaluation of contagion is carried out by testing the hypotheses:

$$\begin{aligned} H_0 &: \rho_{VA} = \rho_{PC}, \\ H_1 &: \rho_{VA} \neq \rho_{PC}. \end{aligned} \tag{5}$$

where ρ_{VA} is the cross-correlation coefficient in the pre-crisis period, and the null hypothesis states that there is no contagion. The *Z*-statistic, which is asymptotically a standard normal random variable, tests the null of no contagion, that is, the equality of the crisis with pre-crisis cross-market correlation coefficients (Southall, 2008, p. 47). The test is performed with the Fisher (1921) z-transformation of sample correlation coefficients. If the absolute value of the Z-statistic is greater than the critical value, the null hypothesis of identical correlation coefficients can be rejected.

4. Effect of Increasing Cross – Market Correlations in the Crisis Period

The data consists of monthly logarithmic returns of the major CEE stock market indexes (i.e. WIG, PX, BUX, SBI TOP, SAX, OMXV, OMXT and OMXR), and the New York market index – S&P500. There are 108 monthly observations for each series for the period beginning May 2004 and ending April 2013 (nine years). In order to employ the procedure described in Section 2, the data was extended to the period from Sept 2003 to Dec 2013 (eight months back and forward). All analyses are conducted using the open-source computer software Gretl 1.9.14 (Adkins, 2013).

4.1. Preliminary Statistics

Table 1 reports summarized statistics for the monthly logarithmic returns for nine stock indexes (in order of decreasing value of market capitalization at the end of 2012), as well as statistics testing for normality.

Table 1. Summarized statistics for the monthly logarithmic returns of nine stock indexes used in the study.

	Market	Index	Market Cap. EUR billion Dec 2012	Mean	Standard deviation	Skewness	Excess kurtosis	Doornik-Hansen test
1	New York	S&P500	10679.7	0.003	0.044	-1.05 [0.00]	2.55 [0.00]	16.18 [0.00]
2	Warsaw	WIG	134.8	0.006	0.065	-0.72 [0.00]	2.56 [0.00]	16.62 [0.00]
3	Prague	PX	28.2	0.002	0.070	-1.24 [0.00]	4.12 [0.00]	21.79 [0.00]
4	Budapest	BUX	15.7	0.005	0.075	-0.94 [0.00]	2.82 [0.00]	16.27 [0.00]
5	Ljubljana	SBITOP	4.9	-0.003	0.062	-0.32 [0.17]	1.10 [0.02]	7.14 [0.03]
6	Bratislava	SAX	4.1	0.001	0.057	0.86 [0.00]	6.54 [0.00]	61.23 [0.00]
7	Vilnius	OMXV	3.0	0.005	0.086	-0.42 [0.08]	5.11 [0.00]	59.75 [0.00]
8	Tallinn	OMXT	1.8	0.008	0.088	-0.04 [0.85]	4.66 [0.00]	58.91 [0.00]
9	Riga	OMXR	0.8	0.002	0.065	-0.84 [0.00]	2.75 [0.00]	16.64 [0.00]

Source: Authors' calculations (using *Gretl 1.9.14* software)
Notes: The table is based on all sample observations during the period May 2004 – April 2013.
The test statistic for skewness and excess kurtosis is the conventional t-statistic. The Doornik – Hansen test (2008) has a χ^2 distribution if the null hypothesis of normality is true. The numbers in brackets are p- values.

Several results in Table 1 are worth special notice. The sample means are not statistically different from zero. The measure for skewness shows that the return series are skewed, except for the SBI TOP, OMXV and OMXT series. The measure for excess kurtosis shows that all series are highly leptokurtic with respect to the normal distribution. The Doornik–Hansen (2008) test rejects normality for each of the return series at the 5 per cent level of significance.

4.2. Direct Identification of Crisis Periods for the U.S. and the CEE Stock Markets

We employ the procedure of dividing market states into up and down markets to identify crisis periods. Figures 1-2 present the crisis periods for the S&P500 and the CEE stock market indexes obtained from the three-stage procedure described in Section 2. The horizontal axis stands for time (months), and the vertical axis stands for the market index. The vertical lines and light grey areas stand for the crisis periods.

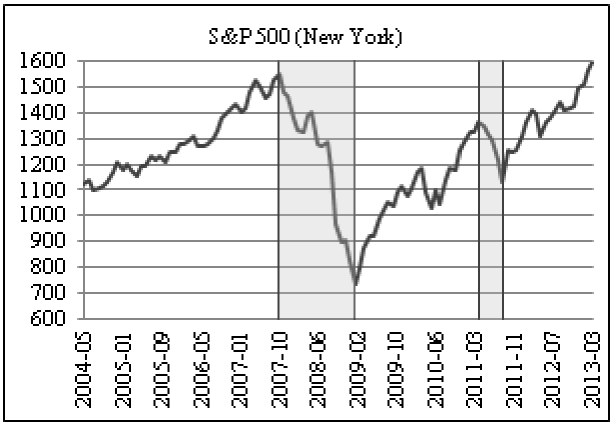

Fig. 1. The period Oct 2007 – Feb 2009 as common crisis and April 2011 – Sept 2011 as an additional down market period for the S&P500 (New York).

To better specify the common crises, we prepare Fig. 3, which expresses overall information about all determined down market periods. We perceive Oct 2007 – Feb 2009 as the common period of the recent global financial crisis for the U.S. and the CEE stock markets, except for Slovakia. In the case of Slovakia we observe a pronounced delay of crisis symptoms. Furthermore, the evidence is that for Slovakia, which accessed the euro area in Jan 1, 2009, the crisis period is much longer and it includes the recent euro area crisis. According to the literature, a balance-of-payments and a fiscal crisis within the European Monetary Union (EMU) started in Spring 2010 (Merler–Pisani–Ferry, 2012). Another important finding of the analysis in Fig. 3 is that we identify additional down market periods in the whole sample for almost all of the examined stock markets. While the additional bear market period on the New York Stock Exchange (S&P500) was undoubtedly not connected with the euro area crisis, we have some doubts in the case of the rest of equity markets investigated, especially as April 2010 is accepted in the literature as the beginning of the euro area crisis period (Merler–Pisani–Ferry, 2012). The most plausible influence of the euro area crisis in the additional subsequent down market periods can be observed in the case of the following indexes: (1) the PX index (April 2010 – May 2012), (2) the BUX index (April 2010 – Sept 2011), and (3) the SBITOP index (Oct 2009 – Sept 2012). It is worthwhile to stress that the Czech Republic (PX) and Hungary (BUX) are not the EMU countries, whereas Slovenia (SBITOP) accessed the euro area in Jan 7, 2007. As can be seen from Fig. 2, the graphs for two EMU countries, i.e. Slovakia (SAX) and Slovenia (SBITOP), are very similar. The aftermath of the euro area crisis is rather obvious in these two cases.

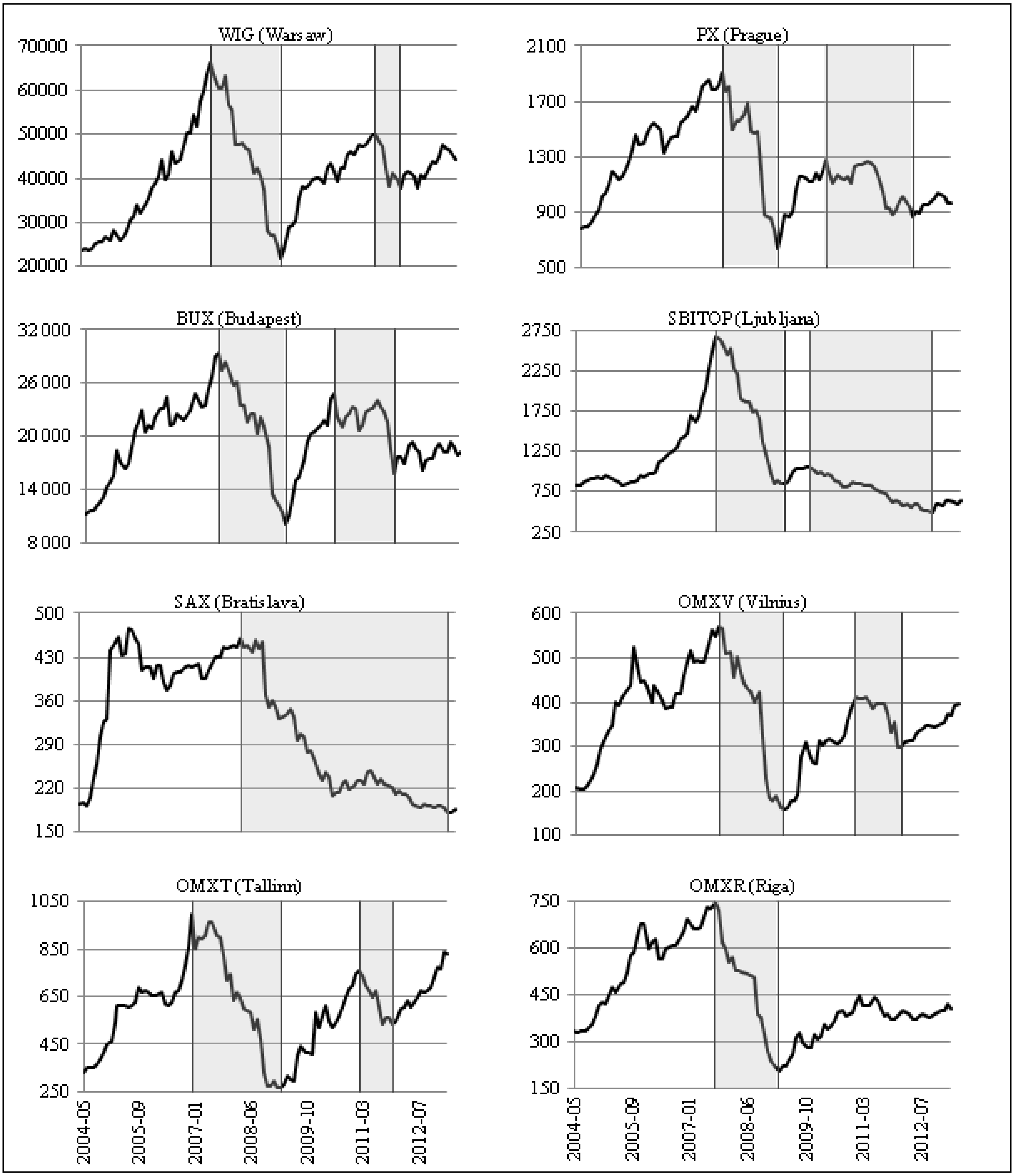

Fig. 2. Crisis periods and additional down markets for the CEE stock market indexes, obtained from the procedure of dividing market states, in the whole sample period May 2004 – April 2013.

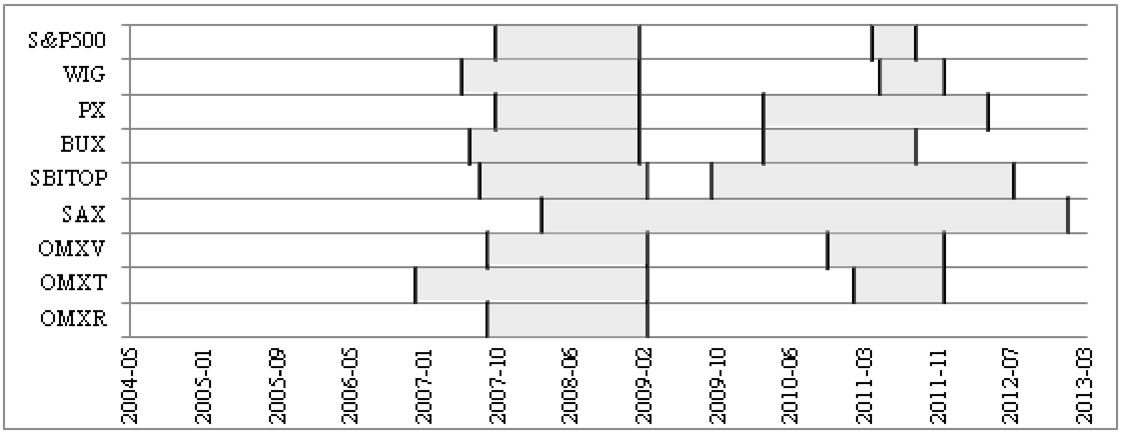

Fig. 3. Overall information about the U.S. and CEE down market periods obtained from the procedure of dividing market states, in the whole sample period May 2004 – April 2013. Down market periods are: (1) 10.2007-02.2009, 04.2011-09.2011 (S&P500); (2) 06.2007-02.2009, 05.2011-12.2011 (WIG); (3) 10.2007-02.2009, 04.2010-05.2012 (PX); (4) 07.2007-02.2009, 04.2010-09.2011 (BUX); (5) 09.2007-03.2009, 10.2009-09.2012 (SBITOP); (6) 03.2008-02.2013 (SAX); (7) 09.2007-03.2009, 11.2010-12.2011 (OMXV); (8) 01.2007-03.2009, 02.2011-12.2011 (OMXT); (9) 09.2007-03.2009 (OMXR). The evidence is that Oct 2007 – Feb 2009 was the common period of the recent global financial crisis, except for the SAX (Bratislava).

4.3. Contemporaneous and Volatility-Adjusted Cross-Market Correlations

The evidence of significant increased correlation in international equity markets in down market periods is well-documented. Our goal is to confirm this observation during the common crisis period of the recent global financial crisis. Table 2 presents standard contemporaneous correlations and volatility-adjusted correlation coefficients, given by Eq. (3), of monthly logarithmic returns on the pairs of indexes S&P500/CEE stock market index (excluding SAX). For comparison, we calculate the dependencies both in the whole sample (May 2004 – April 2013) and in two subsamples of equal size: (1) the pre-crisis period May 2006 – Sept 2007 (17 months), and (2) the common crisis period Oct 2007 – Feb 2009 (17 months). We investigate the cross-market linkages after a shock to the U.S. financial market. Supporting values are equal to: $\hat{\sigma}_C^2 = 0.00362$ (the variance in the high-volatility period in the U.S. stock market) and $\hat{\sigma}_{PC}^2 = 0.00053$ (the variance in the low-volatility period in the U.S. stock market), while the relative increase in the variance of S&P500, given by Eq. (4), is equal to $\delta = 5.8663$. Our results confirm that during the period of high volatility in the U.S. stock market (the common crisis period Oct 2007 – Feb 2009), the estimated conditional cross-correlations between the U.S. and CEE markets were greater than the suitable unconditional volatility-adjusted correlations, however, the *p*-values in brackets inform that contemporaneous correlations are not statistically significant in some cases.

Several results in Table 2 are especially important. There is no reason to reject the null hypothesis of no contagion based on volatility-adjusted cross-market correlations for each of the return series. The Student's *t* critical value is 1.701 (at the 10 per cent level of significance). On the other hand, in the case of contemporaneous cross-market correlations, the conclusions concerning contagion are not such homogenous. As we can observe, the Forbes–Rigobon correction for heteroskedastic bias in index returns leads to a substantial reduction in differences among cross-market correlation coefficients in the pre-crisis and crisis periods. Our results are consistent with the literature and confirm that accommodating heteroskedasticity is valid for detecting contagion across international stock markets, e.g. (Forbes, Rigobon, 2002; Serwa, Bohl, 2005).

Table 2. Contemporaneous cross-correlations and volatility-adjusted cross-correlations of monthly logarithmic returns on pairs S&P500/CEE stock market index (excluding SAX).

	Index	Contemporaneous cross-correlations					Volatility-adjusted cross-correlations		
		Whole sample (1)	Pre-crisis (2)	Crisis (3)			Crisis (3)		
		$\hat{\rho}$	$\hat{\rho}_{PC}$	$\hat{\rho}_{C}$	Z-statistic	Contagion	$\hat{\rho}_{VA}$	Z-statistic	Contagion
1	WIG	0.767 [0.000]	0.438 [0.079]	0.850 [0.000]	2.081	H_1	0.524	0.298	H_0
2	PX	0.750 [0.000]	0.672 [0.003]	0.894 [0.000]	1.659	H_0	0.606	-0.297	H_0
3	BUX	0.744 [0.000]	0.405 [0.107]	0.817 [0.000]	1.900	H_1	0.476	0.232	H_0
4	SBI TOP	0.414 [0.000]	0.114 [0.664]	0.408 [0.104]	0.843	H_0	0.168	0.146	H_0
5	OMXV	0.465 [0.000]	0.145 [0.580]	0.653 [0.005]	1.679	H_0	0.313	0.469	H_0
6	OMXT	0.480 [0.000]	0.374 [0.140]	0.574 [0.016]	0.689	H_0	0.258	-0.340	H_0
7	OMXR	0.386 [0.000]	0.239 [0.356]	0.284 [0.269]	0.128	H_0	0.112	-0.346	H_0

Source: Authors' calculations (using *Gretl 1.9.14* software)

Notes: The table is based on: (1) the whole sample period May 2004 – April 2013; (2) the pre-crisis period May 2006 – Sept 2007 (17 months); (3) the common crisis period Oct 2007 – Feb 2009 (17 months). The table contains contemporaneous correlation coefficients, as well as volatility-adjusted cross-correlation coefficients $\hat{\rho}_{VA}$. *P*-values are given in brackets. Fisher's *Z*-statistic (1921) tests the null of no contagion. The Student's *t* critical value is 1.701 (at the 10% significance level).

5. Conclusion

The purpose of this paper is a direct identification of crisis periods on the eight CEE stock markets, and, for comparison, on the U.S. market. We employ a statistical procedure of dividing market states into up and down markets. Our aim is to examine whether crises are common in various countries. The period investigated (May 2004 – April 2013) includes the 2007 U.S. subprime crisis period. We use the Pagan and Sossounov (2003) methodology of dividing market states into bullish and bearish markets, and our results confirm Oct 2007 – Feb 2009 as the common period of the recent global financial crisis for the U.S. and CEE stock markets (except Slovakia). Moreover, we identify additional down market periods in the sample investigated, both for the CEE and U.S. markets. For two EMU countries, i.e. Slovakia and Slovenia, we observe a pronounced influence of the euro area crisis, which started in Spring 2010. To sum up, the procedure seems to be successful in locating crisis periods or down markets in time.

Furthermore, we show that the correlation structure between the U.S. and the CEE markets is time-varying, especially during crises. We calculate standard contemporaneous correlations and volatility-adjusted correlation coefficients of monthly logarithmic returns on the pairs of indexes S&P500/CEE stock market index (excluding SAX). For comparison, we calculate the dependencies both in the whole sample and in two subsamples of equal size: (1) the pre-crisis period May 2006 – Sept 2007 (17 months), and (2) the common crisis period Oct 2007 – Feb 2009 (17 months). Our empirical findings confirm that accommodating heteroskedasticity is crucial for detecting contagion across stock markets. The presented results are in accord with the existing literature.

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